

Articles

Pediatric Hospital Admissions for Measles Lessons From the 1990 Epidemic

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To examine the descriptive epidemiology of serious measles complications and associated hospital costs during a major epidemic, we used California population-based hospital discharge data to identify hospital admissions for measles during 1986 through 1990 (ICD-9 code 055, $n = 4,201$). We examined 5-year trends and, for 1990 pediatric epidemic cases ($n = 2,234$), sociodemographic and hospital admission financial data. Hospital admission rates for measles rose significantly between 1986 and 1990. During the 1990 epidemic, preschool children aged 1 to 5 years, Medi-Cal (California's Medicaid) beneficiaries, Hispanics, and those living in urban counties accounted for most hospital admissions. Young infants and residents of southern California and the San Joaquin Valley had the highest risks. Medi-Cal beneficiaries and Asian children were at an increased risk for death during the hospital stay. The average hospital admission cost was \$8,201, and the average length of hospital stay was 4.6 days. Hospital costs amounted to \$18 million, two thirds of which was paid for by Medi-Cal. Measles is a serious disease that can result in severe complications requiring lengthy and costly hospital stays. We must remain alert to its continuing threat, complications, and resulting financial burdens.

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Despite a dramatic 98% decrease in the number of measles cases since the measles vaccine was introduced in 1963, measles continues to occur in epidemic and nonepidemic forms in the United States.¹ The United States experienced a large measles epidemic during 1989 and 1990. In 1990, the peak of the epidemic, 27,786 cases of measles were reported (11.2 cases per 100,000 population). The number of reported measles cases declined to 9,643 in 1991 (3.9 per 100,000)² and 2,200 in 1992 (0.9 cases per 100,000), suggesting that the most recent resurgence of the disease has ended.³

During the 1989-1990 epidemic nationwide, children younger than 5 years had the highest age-specific incidence rates.⁴ The outbreaks were confined primarily to large inner-city areas. Unvaccinated, economically disadvantaged minority group children were most at risk.⁴ The measles incidence was highest for Native Americans, Hispanics, and blacks and lowest for whites.^{1,2,4-8} The epidemic was largely attributed to the failure to vaccinate children at appropriate ages.^{9-14†}

In 1990 California had about 50% of all measles cases in the United States.¹⁰ Statewide, the epidemic occurred

predominantly in children younger than 5 years, in low-income minority communities, and in southern California and the San Joaquin Valley.¹⁵ Preschoolers, particularly infants—363.1 per 100,000 compared with an average incidence rate of 26.2 for all 1989-1990 cases—was the predominant age group affected, with most cases occurring among unvaccinated children.¹⁵ Los Angeles, Orange, Riverside, and San Bernardino counties had the largest number of reported cases.² The highest rates of measles were observed in Kern, San Bernardino, Merced, Riverside, Fresno, and Tulare counties (Karen Swanson, Immunizations Branch, California Department of Health Services, written communication, December 1995).

Measles complications are an accurate measure of the overall health effects of widespread outbreaks. Serious complications require admission to a hospital. During the nationwide outbreak of 1989-1990, more than 19% of the reported cases of measles required admission to a hospital.^{4,15} Despite their importance, little is known about the epidemiology of complicated measles cases.

In this report, we examine the descriptive epidemiology of hospitalized measles cases in California and measure the effects of severe measles among children and the financial burden of hospitalized measles cases on the health care system.

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†See also the editorial by N. J. Smith, MD, MPH; L. G. Dales, MD, MPH; and S. H. Waterman, MD, MPH, "California's 1988-1991 Measles Epidemic—The Last One?" on pages 80-81 of this issue.

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ABBREVIATIONS USED IN TEXT

HMO = health maintenance organization
RR = relative risk

Methods and Data*Data Source*

We used the population-based California Patient Discharge Data Base, obtained from the California Office of Statewide Health Planning and Development. This data set comprised about 3.5 million hospital discharges per year from all general acute care hospitals (about 590 per year) licensed to serve civilian patients. We identified measles-induced hospital admissions using the *International Classification of Diseases, 9th revision, Clinical Modification*,¹⁶ code 055, for the period 1986 to 1990. To calculate population-based hospital admission rates, we used California Department of Finance population estimates for the denominator. In addition, to calculate the hospital admission rates for measles cases, we used summary measles incidence data provided by the Immunizations Branch, Division of Communicable Disease Control, California Department of Health Services. These data included the number of measles cases by age and county of residence, plus the percentage of patients with measles admitted to a hospital.

A total of 4,201 hospital admissions due to measles were identified during the study five-year period. We excluded patients who transferred from other short-term acute care hospitals to tertiary care centers to avoid duplicating cases. These exclusions ranged from 0 for 1986 to 182 for 1990. Therefore, our figures represent incident hospitalized cases only. To assess the epidemiologic characteristics of pediatric measles cases admitted to a hospital during the 1990 epidemic, we further limited our analysis to all 2,052 hospital admissions occasioned by measles among patients younger than 20 years for this year.

Data Elements

The hospital discharge database variables used in this study were race or ethnicity (white, black, Hispanic, and Asian or other); age in years (infants younger than 1 year, preschool children aged 1 to 4 years, school-aged children 5 to 19 years); expected principal source of payment; principal diagnosis code; as many as five secondary diagnoses codes; total hospital charges, including charges for all services rendered in the hospital, except physician fees; length of hospital stay in days; and disposition at discharge (such as normal, transferred, or died). High data quality and reliability are assured by error tolerance levels for each data element (0.1% for most items) and by periodic reabstracting studies.

Analysis

We calculated trends for the five-year period 1986 to 1990. Hospital admission rates per 100,000 California population were examined by age group and race or ethnicity. For all age groups, we included number of hospi-

TABLE 1.—Hospital Admission Rate for Measles in California, 1986 to 1990*

Year	Measles Hospital Admissions, No.	Reported Measles Cases, No.	Case-Specific Hospital Admissions Rate/10 ⁴ Cases (95% CI)	Hospital Admission Rate/10 ⁴ Residents (95% CI)
1986.....	38	456	8.3 (5.8, 10.9)	0.1 (0.1, 0.2)
1987.....	40	813	4.9 (3.4, 6.4)	0.1 (0.1, 0.2)
1988.....	192	818	23.5 (20.6, 26.4)	0.7 (0.6, 0.8)
1989.....	994	3,061	32.5 (30.8, 34.1)	3.4 (3.2, 3.8)
1990.....	2,937	12,616	23.2 (22.5, 23.9)	9.8 (9.4, 10.2)

CI = confidence interval

*From the California Office of Statewide Planning and Development Hospital Discharge Data Program; Department of Health Services, Division of Communicable Disease Control, and Department of Finance, Demographic Research Unit.

talized cases of measles and total number of reported measles cases. This allowed the computation of case-specific hospital admission rates. We calculated only crude rates because data necessary to calculate adjusted rates were not available. In addition, we computed measles case-specific hospitalization rates according to age, county, and region of residence. To measure the risk for hospitalization, we calculated relative risks (RR) using the lowest risk group as a referent. Statistical significance was determined using 95% confidence intervals. Asians were combined with "other" to be comparable with California population data and made up 84.2% of the category. The most common comorbid conditions were determined by aggregating the second through the fifth diagnoses after the admitting diagnosis. For deaths occurring during the hospital stay, we give death-to-hospitalized case ratios per 1,000 hospital admissions by age group. We examined measles-related mortality by type of health insurance to assess the association of socioeconomic status with hospital mortality.

Using available data on hospital admission charges and length of stay, we estimated the total costs of measles hospitalizations, average charge per hospital admission, average number of days in hospital, and total number of days by type of health insurance coverage among the 1990 cases. Computations of the averages were based on all hospitalized measles cases with hospital cost information (95.9%). Excluded were 92 cases with unknown or unreported cost information, principally (94.6%) health maintenance organization (HMO) patients. Kaiser Permanente, the largest HMO in California, was exempt from reporting hospital costs. Cost information was limited to inpatient charges and excludes physician fees.

Results*Recent Trends*

As shown in Table 1, the number of hospital admissions in California due to measles rose dramatically from 38 in 1986 to 2,937 in 1990. The case-specific hospital admission rate increased unevenly, from 8.3 per 100 measles cases in 1986 to 23.2 in 1990, with a peak of 32.5 in 1989. The population-based hospital admission rate per 100,000 increased from 0.1 in 1986 to 9.8 in 1990.

TABLE 2.—Measles Hospitalizations by Age and Race or Ethnicity Among Children and Adolescents in California, 1990*

Characteristic	Hospital Admissions, No.	Rate/10 ⁵ Population (95% CI)
All cases 0 to 19 years old . . .	2,052	23.3 (22.3, 24.3)
Age group, yr		
<1	669	122.2 (112.9, 131.4)
1-4	1,050	54.0 (50.7, 57.2)
5-19	333	5.3 (4.7, 5.8)
Race or ethnicity		
White	470	11.6 (10.6, 12.6)
Black	286	40.4 (35.8, 45.1)
Hispanic	1,125	36.2 (34.1, 38.3)
Asian and other†	171	18.3 (15.6, 21.1)

CI = confidence interval

*From the California Office of Statewide Planning and Development Hospital Discharge Data Program and the California Department of Finance, Demographic Research Unit.

†Asians represent 84.2% (144) of this category.

Hospital Admissions for Patients Younger Than 20 Years

Of all hospital admissions for measles in 1990, 70% occurred among those 19 years of age and younger. Nearly a third (32.6%) were infants younger than 1 year, a majority (51.2%) were preschool children aged 1 to 4 years, and the rest (16.2%) were school-aged children 5 to 19 years old (Table 2). The population-based hospital admission rate was 23.3 per 100,000 children. An inverse relationship between age and hospital admission rates was observed. The youngest group had the highest rate (122.2 per 100,000), whereas the rate decreased to 54.0 and 5.3 for the 1 to 4 years and 5 to 19 years age groups, respectively.

Hispanic children constituted a majority (54.8%) of the measles cases admitted to a hospital, followed by whites (22.9%), blacks (13.9%), and Asians and other

TABLE 3.—Measles Case-Specific Hospital Admission Rates by Age and Geographic Region Among Children and Adolescents in California, 1990*

Characteristic	Case-Specific Hospital Admission Rate/100 Cases	Relative Risk (95% CI)
Age group, yr		
<1	26.1	2.54 (2.25, 2.86)
1-4	25.3	2.46 (2.19, 2.76)
5-19	10.3	1.00†
Region‡		
Southern California	27.1	2.94 (1.91, 4.52)
San Joaquin Valley	20.7	2.24 (1.45, 3.47)
San Francisco Bay Area and Central Coast	14.8	1.61 (0.99, 2.60)
Northern California and Sierras	9.1	1.00†

CI = confidence interval

*From the California Department of Health Services, Division of Communicable Disease Control, Immunization Branch, Mandatory Disease Reports.

†Referent group.

‡Southern California: Imperial, Los Angeles, Orange, Riverside, San Bernardino, San Diego, Santa Barbara, and Ventura counties; San Joaquin Valley: Fresno, Kern, Kings, Madera, Merced, San Joaquin, Stanislaus, and Tulare counties; San Francisco Bay Area and Central Coast: Alameda, Contra Costa, Marin, Monterey, Napa, San Benito, San Francisco, San Luis Obispo, San Mateo, Santa Clara, Santa Cruz, Solano, and Sonoma counties; Northern California and Sierras: all other counties.

(8.3%). When assessing these data on a population basis, however, the hospital admission rate was highest for blacks, followed by Hispanics and Asians and other (see Table 2). Whites had the lowest rate.

As shown in Table 3, infants and children aged 1 to 4 years had the highest measles case-specific hospital admission rates. Their risk for hospital admission was 150% higher than that for older children and adolescents (RR = 2.54 and 2.46, respectively). Children residing in southern California had the highest case-specific hospitalization rates, followed by those residing in the San Joaquin Valley and the San Francisco Bay Area or Central Coast. Compared with children in the northern California and Sierras regions, those residing elsewhere in the state had significantly elevated risks for hospital admission. Children residing in southern California and the San Joaquin Valley were significantly at the highest risk for admission to a hospital (RR = 2.94 and 2.24, respectively).

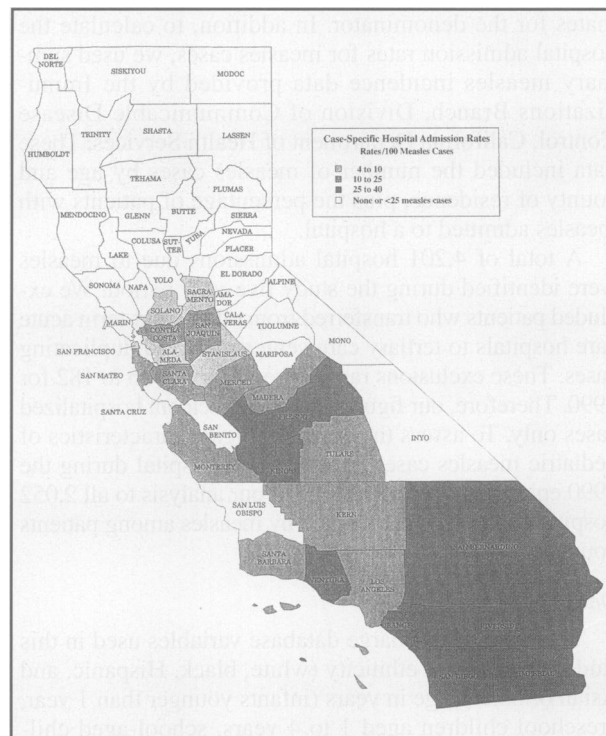


Figure 1.—Measles case-specific hospital admission rates for the 1990 epidemic are shown by California counties.

Figure 1 shows the case-specific hospitalization rates among measles cases throughout the 58 counties in the state. Among counties with at least 25 measles cases, hospital admission rates ranged from a high of 37.4 per 100 in San Bernardino County to a low of 4.9 per 100 in Stanislaus County. A pronounced geographic clustering of high case-specific hospitalization rates was observed in southern California and San Joaquin Valley counties.

Hospitalized Cases by Type of Complication

Few comorbid conditions were substantial contributors to hospital admissions for measles in 1990 (Table 4).

The most common complications resulting from measles were either a result of fluid loss, secondary infection, or acute organ involvement. The main complication was a disorder of fluid, electrolyte, and acid-base balance found in nearly a third of the cases. Further analysis of the specific diagnoses among these cases showed that nearly all of them were due to volume depletion. Otitis media was the second largest complication, present in nearly a fifth of the patients.

Measles-Associated Deaths

A total of 22 children died in hospital, for a death-to-hospitalized case ratio of 1%. The primary cause of death among these children was measles pneumonia. Of the deaths, 15 (68%) were in the 1 to 4 years age group, with the ratio being 1.3 (compared with 0.7 and 0.6 among infants younger than 1 and children aged 5 to 19 years, respectively). Children who were Medi-Cal beneficiaries had an increased mortality risk and accounted for 86% of the deaths (19 of the 22 deaths) when they were 62% of cases. Asian children had the highest mortality risk, accounting for 41% of all measles deaths and only 8% of the hospitalized cases. All other racial or ethnic groups were underrepresented in measles-related mortality. Residents of Fresno County were overrepresented among measles-related deaths, with 32% of all deaths and 6% of all hospitalized cases.

TABLE 4.—Measles Complications Among Hospitalized Children Aged 0 to 19 in California, 1990*

Complication	Hospital Admissions, No.	(%)
Disorder of fluid, electrolyte, and acid balance	652	(31.8)
Otitis media	382	(18.6)
Acute laryngitis and tracheitis	176	(8.6)
Noninfectious enteritis and colitis	170	(8.3)
Pneumonia	133	(6.5)
Multiple others	539	(26.3)
Total	2,052	(100.0)

*From the California Office of Statewide Planning and Development Hospital Discharge Data Program.

Hospital Costs and Length of Hospital Stay

For all patients younger than 20 years admitted to a hospital for measles during 1990, the average number of days in hospital was 4.6 and the average cost per hospital stay was \$8,201 (Table 5). The preschool-aged group had the highest average cost (\$9,034), the highest total costs for hospital admission (\$10.1 million, 57.3% of the total), and the highest number of days in the hospital (5,280, 54.2% of total). The average number of days in hospital was 4.7 among preschoolers. As also shown in Table 5, the infant group younger than 1 year also had higher hospital costs and longer hospital stays than the oldest group. The total cost of the hospital stay for the 9,742 hospital days among all pediatric cases amounted to \$17.6 million. To estimate the hospital costs for the 92 cases with unreported or unknown cost information, we used the average

TABLE 5.—Hospital Costs and Length of Stay by Age Group and Health Insurance Coverage Among California Children and Adolescents With Measles Admitted to a Hospital, 1990*†

Age Group, yr, by Insurance Coverage, No.	Average Cost/ Hospital Admission, \$	Total Costs for Hospital Admissions, \$ × 10 ³	Average Days in Hospital, No.	Total Days, No.
<1	8,374	5,987	4.7	3,357
Medi-Cal	9,438	4,700	5.0	2,463
Private insurance	5,652	384	4.0	271
HMO	4,288	274	3.4	220
Self-pay	8,129	553	4.9	332
Other	4,454	76	4.2	71
1-4	9,034	10,073	4.7	5,280
Medi-Cal	10,634	8,018	5.1	3,837
Private insurance	5,140	6,940	3.8	517
HMO	5,062	557	3.7	404
Self-pay	7,006	581	4.4	367
Other	6,745	223	4.7	155
5-19	4,827	1,506	3.5	1,105
Medi-Cal	5,099	607	3.5	421
Private insurance	4,665	345	3.5	259
HMO	3,707	234	3.1	198
Self-pay	5,280	169	3.7	117
Other	6,307	151	4.6	110
All ≤19	8,201	17,566	4.6	9,742

HMO = health maintenance organization

*From the California Office of Statewide Planning and Development Hospital Discharge Data Program.

†Computation based on cases with hospital cost information (95.9%). For the remaining 92 cases (24, <1 year; 32, 1-4 years; and 36, 5-19 years), charges were unknown or not reported. Of the exclusions, 87 (94.6%) were HMO cases.

hospital cost for HMO cases because the preponderance were such cases. Combining the estimated \$413,372 with our original amount resulted in a rounded total of \$18 million (in 1990 dollars).

Medi-Cal, California's Medicaid program, was the predominant health insurance, accounting for 61.5% of measles cases (Medi-Cal's percentage of all hospital discharges statewide was 19%). Two thirds (67.4%) of hospital admissions among infants younger than 1 year were paid for by Medi-Cal, with the percentage decreasing to 34.2% among those 5 to 19 years. In contrast, for HMOs (14.5%) and private insurance (12.4%), the percentage of cases climbed as age increased.

Overall, Medi-Cal had the highest average and total costs for hospital admissions for measles (\$13.3 million, 75.8% of the total). In addition, Medi-Cal also had the largest number of hospital days (6,721, 69% of the total). It had the highest average cost per hospital stay and longest average length of hospital stay for infants and preschoolers. Self-pay patients, representing only 8.3% of the measles cases younger than 20 years, had the second highest average cost per hospital stay and average number of hospital days among infants.

Discussion

Our study developed an epidemiologic profile of children admitted to a hospital for the treatment of measles and its complications that is consistent with the epidemi-

ologic profile observed among all children with measles.⁴ We found that infants and young children, Medi-Cal beneficiaries, Hispanics, and residents of urban counties accounted for most of the hospitalized measles cases. In addition, we found that the risk for hospital admission among measles cases was highest among children younger than 5 years, which decreased with increasing age, and those residing in southern California and the San Joaquin Valley. Last, our study underscored that measles is a serious disease that can result in severe complications leading to lengthy and costly hospital stays.

Some limitations of our study need to be considered when interpreting these results. The information collected during the study period on the incidence of measles lacks enough detail to allow for the assessment of risk for measles hospital admissions according to race or ethnicity and type of health care coverage. As a result, we were unable to adjust our hospitalization rates for possible confounders to define key independent risk factors. Nonetheless, the descriptive nature of our study allowed us to obtain valuable information on measles severity and the epidemiologic profile of those at risk for measles complications. In addition, our financial data were limited to hospital charges alone. We cannot account for other costs associated with measles and its complications, such as physician fees and outpatient care. Last, we lacked enough clinical detail on the database to measure the immunization status of children admitted to hospital to identify the proportion of hospital admissions due to vaccine failure or the lack of vaccination.

Before 1988, hospital admissions among children with measles were relatively rare in California. The measles epidemic that peaked in 1990 had its onset in 1988 in Los Angeles County¹⁵ and spread quickly to the rest of the state. With the resurgence of measles in 1988, we observed what might be an increase in measles severity. Children with measles were almost five times more likely to be admitted to a hospital during the epidemic years than during the preceding year. In addition, case-fatality rates among hospitalized children were high during the epidemic period, particularly among Asians and Medi-Cal beneficiaries. This finding is consistent with published reports of high fatality rates among the poor and Samoan and Hmong children with measles.¹⁵ Possible explanations for this increase in measles severity are not clear. We speculate that the high proportion of measles cases among infants and young children, in whom measles is usually more severe, could have greatly contributed to increased severity during the epidemic. In addition, changes in the demographic composition of cases, the underreporting of mild cases during epidemic years, and problems with access to medical care among low-income communities could have played a substantial role. The contribution of a delayed onset of primary care to the risk of hospital admission is not clear. Nonetheless, a lack of early, ongoing, adequate primary care could have played a role, at least in some minority and low-income persons who traditionally either underuse services or have more limited access to primary care. Last, the possibility

exists that children may be more freely admitted to a hospital during an epidemic without regard to measles severity. Stratifying our data by days of hospital stay showed, however, that 82% of patients with measles stayed in the hospital for three days or more. Furthermore, the long average length of hospital stay among measles cases supports the notion of high severity during the epidemic.

Nationwide studies show that measles outbreaks have been largely confined to large inner-city areas.^{2,4,6,8,9,11} In our study, we found that the case-specific hospital admission rates for measles were substantially higher in counties located primarily in southern California and the San Joaquin Valley. Furthermore, hospital admission rates were high in both large and small communities. We were unable to determine if rates in some counties with large rural areas were primarily among residents of the larger cities within the county. A report in the literature has documented that the recent influx of immigrants into California's rural communities, such as the Hmong and Hispanics, who do not traditionally immunize their children and have limited access to health insurance, has contributed to the increased risk for measles in some areas of the state.¹⁵

We also found that hospital admissions for measles primarily affected economically disadvantaged and very young children. The greatest majority of pediatric measles cases admitted to a hospital and measles-associated deaths occurred in Medi-Cal beneficiaries or patients who had no health insurance coverage. This observation, coupled with the higher incidence of measles and measles-related hospital stays among racial or ethnic minorities and very young children and infants during the epidemic, suggests the necessity to become sensitive to the health care needs and cultural realities of economically disadvantaged and minority communities. We suggest that the development of effective, culturally sensitive prevention measures targeting these communities may avert the social and financial burdens of measles and its complications. Because most of the costs of hospital admissions for measles were paid for by the public sector, implementing programs that target these communities can possibly save scarce public health care funding.

Although we were unable to do an in-depth cost-benefit analysis because of lack of information, our study showed that the measles epidemic of 1990 resulted in substantial hospital costs and lengthy hospital stays among children with measles. Moreover, using 1990 estimates for vaccinating a child,¹⁰ we estimated that more than 290,000 children could have been vaccinated with the \$18 million spent on hospital costs for the treatment of measles and its complications alone.

To our knowledge, this is the first statewide epidemiologic study of hospital admissions due to measles during a large epidemic. We found that young, minority, and economically disadvantaged children residing in southern California and the San Joaquin Valley were most likely to have serious cases of measles requiring admission to a hospital. We also documented that California's public medical sector had to pay for most hospital costs associ-

ated with the epidemic. Moreover, we showed that children admitted to a hospital for the treatment of measles complications had a variety of serious problems requiring lengthy and costly hospital stays and resulting in increased mortality. Measles is clearly not a trivial illness and has substantial morbidity and mortality associated with its occurrence in large outbreaks. We must remain vigilant to the potential for serious complications when measles develops and the need to effectively use appropriate primary prevention measures.

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